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The Relative Effects of Skill Formation and Job Matching on Wage Growth in Ethiopia

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Estimated age and job seniority profiles of wages and marginal productivity in Ethiopia suggest that both skill formation and job matching significantly affect growth of wages and productivity over time However, job matching is by far the more important of the two sources of growth in wages and productivity

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Summary findings

Mengistae analyzes production and labor market data for a random selection of small to medium-size firms in Ethiopia to answer two questions:

- Does a worker's marginal productivity increase with time in the labor market or with job seniority, as must be the case if on-the-job skill formation or job matching has anything to do with the dynamics of wages observed in the data?
- Assuming that marginal productivity grows with experience or seniority, is skill formation more or less important than job matching as a source of growth in productivity?

The main feature of Mengistae's analysis is the joint regression of the log of the average product of hours in a firm and the log of average hourly earnings of a firm's employees on the shares of experience-seniority cells of workers in total annual hours in the firm.

Marginal productivity falls as experience in the labor market passes the 15-year mark, but the expected marginal product of a mobile worker with 16 or more years of experience is still nearly 80 percent higher than that of the base group.

The between-jobs growth of hourly wages with potential experience is also large, but not as large as growth in marginal productivity for workers with less than 15 years of experience.

Mengistae concludes that job matching is far more important than skill formation as a source of growth in productivity. Net mobility gains account for at least twice the share of the return to skill formation in the observed between-jobs growth of wages with market experience.

The rate of return to skills formation is higher in the United States than in Ethiopia. The relative return to skills formation is probably lower in Ethiopia partly because the flow of information about the labor market is more restricted there.

This paper — a product of the Development Research Group — is part of a larger effort in the group to identify firm-level sources of growth in productivity. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Anna Regina Bonfield, room MC3-354, telephone 202-473-1248, fax 202-522-3518, Internet address abonfield@worldbank.org. Policy Research Working Papers are also posted on the Web at http://www.worldbank.org/html/dec/Publications/Workpapers/home.html. The author may be contacted at tmengistae@worldbank.org. April 1999 (41 pages).

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1 Introduction

The concavity of individual wage rates in labour market experience and job seniority is a well established empirical regularity. Also well known is the fact that the phenomenon is consistent with a range of competing models of wage determination. On the one hand, we have implicit contract models predicting rising experience and seniority profiles of wages against flat profiles of marginal productivity as a mechanism of income insurance for workers against ability risk (Harris and Holmstrom, 1982) or the labour market's solution to the problem of moral hazard (Lazear, 1979, 1981) or adverse selection (Salop and Salop, 1976). In contrast to these, human capital theory and the hypothesis of job-matching[1] associate rising profiles of wages with a rising profile of marginal productivity. According to the theory of human

[1] I use this phrase quite broadly as a characterisation of models of permanent and voluntary job separation in which a worker's mobility decisions depend on the arrival of information on the quality of the current job match given outside alternatives or on prospective matches given the worker's perception of the quality of the current match. The reference therefore includes Burdett's (1978) model of on-the-job search and the job shopping models of Johnson (1978) and Jovanovic(1979) as extreme abstractions in which skill formation, uncertainity and information asymmetry are all assumed away, as well as their extensions to take one or more of these into account as in Jovanovic (1979b,1984), Mortensten (1988) and Topel (1991).

capital, a worker earns more as he gets older because his marginal product increases with time in the labour market as return to on-the-job investment in general skills (Becker, 1962; Mincer, 1962, 1974; Ben Porath, 1967; Heckman, 1974). Likewise, wages rise with job seniority because marginal productivity grows with time on a job as return to investment in firm specific skills (Becker, 1962; Oi, 1962; and Hashimoto, 1979). Moreover, on-the-job general skill formation is financed entirely by the worker by means of earning less than the value of his marginal product for the duration of the investment. The cost of investment in specific skills is shared between the worker and the firm by means of the worker earning more than the value of his marginal product over the duration of investment but giving up a share of the returns thereafter.

Neither of these temporal wedges between wages and marginal productivity is operational in models of pure job matching. In such models a worker is assumed to earn his spot marginal product and the growth of marginal productivity with time in the labour market or with job seniority arises simply as a sample selection effect of mobility decisions. As in basic models of human capital theory, uncertainty and information asymmetry are assumed away and job separation is always voluntary and permanent. However, there is no room for on-the-job skill formation since a worker's intrinsic potential productivity is predetermined in relation to whatever happens following entry to the labour market or the assumption of a particular job. What changes during time in the labour market or tenure over a job is not the worker's skill but the amount of information available to him on his relative marginal productivity in alternative job matches as the basis for mobility decisions. Underlying an observed distribution of individual wage rates is therefore a distribution of the marginal productivity of matches rather than of individuals *per se*. In a world where jobs are 'pure inspection goods', as is the case in Burdett's (1978) model, mobility decisions are made upon the arrival of information on the productivity of prospective matches. Consequently, the expected marginal product of a worker must be larger than that of a younger worker in a cross section on account of being better matched to his current job, having sampled and rejected a larger number of alternatives. In the opposite world where jobs are 'pure experience goods', as is the case in the Jovanovic (1979) model, mobility decisions are based on new information on the marginal productivity of the current match. Here, a senior worker on a job has a higher expected marginal product than a junior worker because senior workers are less uncertain of the true productivity of their match and, consequently, include fewer poorly matched workers. In an extension of Burdett's model, Topel (1991) proposes one in which, in sharp contrast to the Jovanovic model, mobility biases can create the appearance of marginal productivity and wages falling with job-seniority despite the fact that the more productive is a job match the more durable it is as in Jovanovic (1979).[2]

In this paper, I analyse production and labour market data on a random selection of small to medium sized manufacturing firms in Ethiopia in order to answer two complementary questions. First, does a worker's marginal productivity increase with time in the labour market or with job seniority, as must be the case if on-the-job skill formation or job matching have anything to do with the dynamics of wages as observed in the data? Secondly, assuming that marginal productivity does indeed grow with labour market experience or job seniority, how important is skill formation relative to match effects as a source of growth in productivity? The main feature of the analysis is the joint regression of the log of the average product of hours in a firm and the log of average hourly earnings of its employees on the shares of experience-seniority cells of workers in total annual hours in the firm. Although there is evidence that both marginal product and the wage rate rise with job-seniority, the amount by which they do so is very small. However, both do grow substantially with market experience. Taking workers in the 0-5 years experience-seniority cell as the base group, I find that the expected marginal product of a fully mobile worker[3] grows by 65 per cent relative to the base as experience increases from 5 to 10 years. A further 5 year increase in experience raises expected marginal product to more than double that of the base group assuming mobility is maintained. Marginal productivity falls as market experience passes the 15-year mark, but the expected marginal product of a mobile worker with 16 years or more experience is still nearly 80 per cent higher than that of the base group. The between-jobs growth of hourly wages with potential experience is also large, but not as large as growth in marginal productivity for workers with less than fifteen years of experience. This and the fact that I cannot reject the null that older workers earn their marginal product is evidence that at least some of the observed

[2]The empirical framework to be developed in the next section is based on Topel (1991) because of the model's generality in that it generates predictions about the effects of job matching on the experience and seniority profiles of wages and productivity without assuming away skill formation, uncertainty or information asymmetry.

[3]By a 'fully mobile worker' I mean a worker who changes jobs at least once every five years.

growth in wages is return to general skill formation. However, there is also evidence of significant mobility effects in the same growth. Indeed, individual earning function analysis of data on workers sampled from the same firms and time periods for which the firm level average productivity and average wage equations are estimated indicates that mobility gains are by far the single most important source of the observed between-jobs growth of wages with experience. The ratio of the estimated net mobility gain to between-jobs wage growth due to other sources including skill formation ranges from 1.9 to 3.5.

To my knowledge, this is the first attempt at simultaneously testing for skill formation and mobility effects in wage growth. The rest of the paper is organised as follows. Section 2 proposes an empirical framework in which the job-matching and skill formation hypotheses can be tested using firm level cross-section data on work force characteristics and compensation. Results of the application of the method to the Ethiopian data are presented in Section 3. I conclude with a summary and a brief assessment in Section 4.

2 Empirical Framework

2.1 Estimating Profiles of Relative Marginal Productivity and Relative Wages

Consider a population of n workers distributed as full time employees between m firms. Let w_{ij} be the hourly wage worker i is observed to earn as an employee of firm j where $i = 1,..,n$ and $j = 1,...,m$. Let also y_{ij}, $i = 1,...,n$, $j = 1,...,m$, be the corresponding hourly product of worker i in firm j, defined as the hourly value added of i given other production inputs in j. I shall assume, for the time being, that all workers are identical with respect to observable characteristics influencing earnings or productivity with the exception of two variables, namely, time in the labour market in years, X_{1ij}, and time on the current job in years, X_{2ij}. I will also assume that w_{ij} and y_{ij} are log linear in X_{1ij} and X_{2ij} so that[4]

[4]Second and higher order terms in market experience and job seniority will be introduced in the empirical work to be reported as will be other observable characteristics such as schooling. As will be evident later, their suppression in the specification of the earning and productivity functions considered here does not involve any loss of generality to the statements made in this section.

$$\ln w_{ij} = X_{1ij}\alpha_1^s + X_{2ij}\alpha_2^s + \epsilon_{ij}^w \tag{1}$$

and

$$\ln y_{ij} = X_{1ij}\beta_1^s + X_{2ij}\beta_2^s + \epsilon_{ij}^y \tag{2}$$

where, α_1^s, α_2^s, β_1^s and β_2^s are constants and ϵ_{ij}^w and ϵ_{ij}^y are random error terms summing up influences of unobservables. The parameter α_1^s measures the expected return to an additional year in the labour market while α_2^s is the expected return to an additional year on the current job. A rising experience profile of wages means α_1^s is positive, while a rising job seniority profile of wages means α_2^s is positive. Either of these cases is observed in the data if there is on-the-job acquisition of skills, or wage determination involves, for example, a scheme of income insurance for workers, as in the model of Harris and Holmstrom (1982), or deferment of compensation as a disciplining or screening device, as in Lazear (1979, 1981) or Salop and Salop (1976). The observation $\alpha_1^s > 0$ or $\alpha_2^s > 0$ is therefore a necessary but not sufficient condition for not rejecting the skill-formation hypothesis. A sufficient condition for not rejecting the same hypothesis is the observation $\beta_1^s > 0$ given $\alpha_1^s > 0$ or the observation $\beta_2^s > 0$ given $\alpha_2^s > 0$.

The job-matching hypothesis is the proposition that an existing job match is dissolved by a worker only in favour of a more productive one so that the more productive is the current match the more durable it is. If this is indeed the case, the error terms ϵ_{ij}^w and ϵ_{ij}^y must be correlated with the regressors X_{1ij} and X_{2ij} in equations 2.1 and 2.2. Consequently, the application of ordinary least squares to either equation will produce biased estimates of the true effects of market experience and job seniority even in the absence of individual heterogeneity in unobserved ability. Following Topel (1991), let

$$\epsilon_{ij}^w = \phi_{ij}^w + \mu_i^w + \nu_{ij}^w \tag{3}$$

and

$$\epsilon_{ij}^y = \phi_{ij}^y + \mu_i^y + \nu_{ij}^y \tag{4}$$

where ϕ_{ij}^w and ϕ_{ij}^y are match effects, μ_i^w and μ_i^y are individual effects and ν_{ij}^w and ν_{ij}^y are iid, zero-mean error terms orthogonal to experience, job-seniority, match effects and individual effects such that $E(\nu_{ij}^w, \nu_{ij}^y) = \sigma_{wy}^\nu$. Assume further that

$$\phi^w_{ij} = X_{1ij}a^\phi_1 + X_{2ij}a^\phi_2 + u^{\phi w}_{ij} \tag{5}$$

$$\phi^y_{ij} = X_{1ij}b^\phi_1 + X_{2ij}b^\phi_2 + u^{\phi w}_{ij} \tag{6}$$

$$\mu^w_i = X_{2ij}a^\mu_2 + u^{\mu w}_{ij} \tag{7}$$

$$\mu^y_i = X_{2ij}b^\mu_2 + u^{\mu y}_{ij} \tag{8}$$

where a^ϕ_1, a^ϕ_2, a^μ_2, b^ϕ_1, b^ϕ_2, and b^μ_2 are constants and each of $u^{\phi w}_{ij}$, $u^{\phi w}_{ij}$, $u^{\mu w}_{ij}$ $u^{\mu y}_{ij}$ is an iid zero-mean error term orthogonal to X_{1ij}, X_{2ij}, ν^w_{ij} and ν^y_{ij}.[5] In general, existing evidence is $a^\mu_2, b^\mu_2 > 0$, that is, other things being equal, more able workers are less mobile.[6] I shall take Topel's (1991) search and match technology as a working hypothesis in what follows to assume $a^\phi_1, b^\phi_1 > 0$ and $a^\phi_2, b^\phi_2 < 0$ but $a^\phi_1 + a^\phi_2, b^\phi_1 + b^\phi_2 > 0$. The first of these inequalities states the implication of the same technology that the current wage of an individual is the maximum offer he has had since joining the labour market which, in terms of the productivity equation, means that the current match is at least as productive as any of the alternative matches he has inspected to date. The second is a statement of the implication that mobility occurs only if it pays so that, in view of $\alpha^s_2, \beta^s_2 > 0$, the expected wage/marginal product of movers at their initial jobs is higher than the expected wage/marginal product of stayers.[7]. The third inequality is a statement of two propositions, namely, that the more paying or productive is a match, the more durable it is, and that the net gain from mobility of movers is positive. The first of these can be read, for example, from equation 2.5 by rewriting it as

$$\phi^w_{ij} = X^0_{1ij}a^\phi_1 + X_{2ij}(a^\phi_1 + a^\phi_2) + u^{\phi w}_{ij} \tag{9}$$

[5]Equations (2.7) and (2.8) imply $E(X_{1ij}\mu_i) = 0$. This is not a strong assumption since it only means that unobserved ability cannot differ systematically between generations of workers.

[6]See, for example, Mincer and Jovanovic (1981). As will be reported later, there is evidence of a positive correlation between job-seniority and unobserved ability in the data anlysed here as well.

[7]It should be noted that this does not apply if there is no true return to job seniority in terms of wages or productivity. The result also assumes the absence of on-the-job search costs or that such costs are always less than mobility costs (Topel, 1991).

where $X^0_{1ij} \equiv X_{1ij} - X_{2ij}$, is initial market experience. The second can be read from the same equation by rewriting it as

$$\phi^w_{ij} = -X^0_{1ij} a^\phi_2 + X_{1ij}(a^\phi_1 + a^\phi_2) + u^{\phi w}_{ij} \tag{10}$$

Substituting from equations 2.5 and 2.7 into equation 2.1 and from equations 2.6 and 2.8 into 2.2 gives

$$\ln w_{ij} = X_{1ij}\alpha_1 + X_{2ij}\alpha_2 + \eta^w_{ij} \tag{11}$$

and

$$\ln y_{ij} = X_{1ij}\beta_1 + X_{2ij}\beta_2 + \eta^y_{ij} \tag{12}$$

where

$$\begin{aligned} \alpha_1 &= \alpha^s_1 + a^\phi_1 \\ \alpha_2 &= \alpha^s_2 + a^\phi_2 + a^\mu_2 \end{aligned} \tag{13}$$

$$\begin{aligned} \beta_1 &= \beta^s_1 + b^\phi_1 \\ \beta_2 &= \beta^s_2 + b^\phi_2 + b^\mu_2 \end{aligned} \tag{14}$$

$$\begin{aligned} \eta^w_{ij} &= \nu^w_{ij} + u^{\phi w}_{ij} + u^{\mu w}_{ij} \\ \eta^y_{ij} &= \nu^y_{ij} + u^{\phi y}_{ij} + u^{\mu y}_{ij} \end{aligned} \tag{15}$$

and $E(\eta^w_{ij}\eta^y_{ij}) = \sigma^\eta_{wy}$.

If y_{ij} were directly observable, least squares applied to 2.11 and 2.12 would yield consistent estimates of the parameters α_1, α_2, $\beta_1$and β_2. While such estimates would not be useful to test for a skill formation effect or a match effect separately, they would nonetheless suffice as a basis for testing the null that neither of the two effects is present in the data. The null is rejected if we observe that $\beta_1 > 0$ given $\alpha_1 > 0$ or $\beta_2 > 0$ given $\alpha_2 > 0$.

Although y_{ij} is not directly observable, firm level average productivity of hours is. The fact that the latter is a function of the firm level average of y_{ij} can then be exploited to obtain estimates of the parameters of equations 2.11 and 2.12 on the basis of firm level observations of the average wage rate and the average productivity of hours. Define the following dummy variables: $D^X_{1ij} = 1$ if $X_{1ij} < k_1$; $D^T_{1ij} = 1$ if $X_{2ij} < k_1$; $D^X_{Gij} = 1$ if $X_{1ij} > k_G$; $D^T_{Gij} = 1$ if $X_{2ij} > k_G$; $D^X_{gij} = 1$ if $k_{g-1} \leq X_{1ij} < k_g, g = 2, ...G$; and $D^T_{gij} = 1$ if

$k_{g-1} \leq X_{2ij} < k_g, g = 2, ...G$; where k_1, k_g and k_G are known constants. Let also α_{11}, α_{21}, α_{1g} and α_{2g} be constants such that

$$\begin{aligned} X_{1ij}\alpha_1 &= \alpha_{11} + \sum_{g=2}^{G} \alpha_{1g} D_{gij}^X \\ X_{2ij}\alpha_2 &= \alpha_{21} + \sum_{g=2}^{G} \alpha_{2g} D_{gij}^T \end{aligned}$$

Equation 2.11 can then be written in terms of dummy variables of experience-seniority intervals as

$$\ln w_{ij} = \alpha_0 + \sum_{g=2}^{G} \alpha_{1g} D_{gij}^X + \sum_{g=2}^{G} \alpha_{2g} D_{gij}^T + \eta_{ij}^w \tag{16}$$

where $\alpha_0 = \alpha_{11} + \alpha_{21}$. With a similar definition of parameters β_{11}, β_{21}, β_{1g} and β_{2g}, equation 2.12 can likewise be written as

$$\ln y_{ij} = \beta_0 + \sum_{g=2}^{G} \beta_{1g} D_{gij}^X + \sum_{g=2}^{G} \beta_{2g} D_{gij}^T + \eta_{ij}^y \tag{17}$$

where $\beta_0 = \beta_{11} + \beta_{21}$.

It might be worth noting at this point that any specification of the earning or productivity equation involving second or higher order terms in experience and job seniority can be arrived at as the limiting function to which equation 2.16 or 2.17 approaches as G tends to infinity. No loss of generality is therefore entailed by the fact that I started off by suppressing the terms in arriving at the same equations. It is also more convenient to express the equations in dummy variables for experience-seniority cells of observations rather than in those for experience or seniority intervals. Assume, for example, that $G = 3$, suppress worker and employer subscripts and define dummy variables as follows: $D_{gh} = D_g^X D_h^T$, $g, h = 1, ..., G$ so that $D_{gh} = 1$ if $D_g^X = 1$ and $D_h^T = 1$, but $D_{gh} = 0$, otherwise. Equation 2.16 can then be written as

$$\ln w = \alpha_0 + \alpha_{12} D_{21} + \alpha_{13} D_{31} + (\alpha_{12} + \alpha_{22}) D_{22} + (\alpha_{13} + \alpha_{32}) D_{32} + (\alpha_{13} + \alpha_{33}) D_{33} + \eta^w \tag{18}$$

In view of 2.13, each of the coefficients α_{12} and α_{13} is composed of a true experience effect, α_g^s, and a mobility gain or match improvement effect, a_g^ϕ, so that

$$\alpha_{1g} = \alpha_g^s + a_g^\phi \tag{19}$$

where $a_g^\phi > 0, g = 2,3$. Consider, in contrast, the expected experience and seniority premium of a non-mobile worker at experience level g. This cannot include a mobility gain but does include a true experience effect, α_g^s, a true seniority effect, α_{gg}^s, a match quality effect, a_{gg}^ϕ, and an unobservable ability effect a_{gg}^μ, so that we have, in equation 2.18,

$$\alpha_{1g} + \alpha_{gg} = \alpha_g^s + \alpha_{gg}^s + a_{gg}^\phi + a_{gg}^\mu \tag{20}$$

and, hence,

$$\alpha_{gg} = \alpha_{gg}^s + a_{gg}^\phi + a_{gg}^\mu - a_g^\phi \tag{21}$$

Consider next the expected experience and seniority premium of a worker at experience level g but in an intermediate state of mobility, i.e., at seniority level h such that $1 < h < g$. This must have the same components as the expected premium of a non-mobile worker except that, like the expected premium of a fully mobile worker, it includes a mobility gain, $a_g^{\phi h}$, so that

$$\alpha_{1g} + \alpha_{gh} = \alpha_g^s + \alpha_{gh}^s + a_{gh}^\phi + a_{gh}^\mu + a_g^{\phi h} \tag{22}$$

where, $1 < h < g$. Hence,

$$\alpha_{gh} = \alpha_{gh}^s + a_{gh}^\phi + a_{gh}^\mu + a_g^{\phi h} - a_g^\phi \tag{23}$$

Going back to equation 2.18, denote

$$\begin{aligned} \lambda_g &= 1 + \alpha_{1g} \\ \lambda_{gh} &= 1 + \alpha_{2h}/\lambda_g \end{aligned} \tag{24}$$

so that $\lambda_g \lambda_{gh} = 1 + \alpha_{1g} + \alpha_{2h}$. The equation can then be written as

$$\begin{aligned} \ln w &= \alpha_0 + (\lambda_2 - 1)D_{21} + (\lambda_3 - 1)D_{31} + (\lambda_2\lambda_{22} - 1)D_{22} \\ &\quad + (\lambda_3\lambda_{32} - 1)D_{32} + (\lambda_3\lambda_{33} - 1)D_{33} + \eta^w \end{aligned} \tag{25}$$

Likewise, equation 2.17 can be written as

$$\begin{aligned} \ln y &= \beta_0 + (\delta_2 - 1)D_{21} + (\delta_3 - 1)D_{31} + (\delta_2\delta_{22} - 1)D_{22} \\ &\quad + (\delta_3\delta_{32} - 1)D_{32} + (\delta_3\delta_{33} - 1)D_{33} + \eta^y \end{aligned} \tag{26}$$

where,

$$\begin{aligned} \delta_g &= 1 + \beta_{1g} \\ \delta_{gh} &= 1 + \beta_{2h}/\delta_g \end{aligned} \tag{27}$$

so that $\delta_g \delta_{gh} = 1 + \beta_{1g} + \beta_{2h}$,

$$\begin{aligned} \beta_{1g} &= \beta^s_g + b^\phi_g \\ \beta_{gg} &= \beta^s_{gg} + b^\phi_{gg} + b^\mu_{gg} - b^\phi_g \\ \beta_{gh} &= \beta^s_{gh} + b^\phi_{gh} + b^\mu_{gh} + b^{\phi h}_g - b^\phi_g, 1 < h < g \end{aligned} \tag{28}$$

where the components of β_{1g}, β_{gg} and β_{gh} are defined in strict analogy to those of α_{1g}, α_{gg} and α_{gh}. Consider the average hourly wage, $\overline{w}_j$, of workers employed in firm j. Equation 2.25 means[8]

$$\begin{aligned} \overline{w}_j &= (1/n_j) \exp \alpha_0 \sum_{i=1}^{n_j} (1 + (\lambda_2 - 1) D_{21ij} + (\lambda_3 - 1) D_{31ij} + (\lambda_2 \lambda_{22} - 1) D_{22ij} \\ &\quad + (\lambda_3 \lambda_{32} - 1) D_{32ij} + (\lambda_3 \lambda_{33} - 1) D_{33ij} + \eta^w_{ij} \end{aligned}$$

where n_j is the number of workers in firm j. This leads to the firm level average wage rate equation

$$\begin{aligned} \ln \overline{w}_j &= \alpha_0 + \ln[1 + (\lambda_2 - 1) P_{21j} + (\lambda_3 - 1) P_{31j} + (\lambda_2 \lambda_{22} - 1) P_{22j} \\ &\quad + (\lambda_3 \lambda_{32} - 1) P_{32j} + (\lambda_3 \lambda_{33} - 1) P_{33j} + \overline{\eta}^w_j] \end{aligned} \tag{29}$$

where $\overline{\eta}^w_j = 1/n_j \sum_{i=1}^{n_j} \eta^w_{ij}$, $P_{ghj} = n_{ghj}/n_j$, and n_{ghj} is the number of workers of experience level g and seniority level h in firm j so that, assuming the same number of hours for each worker, P_{ghj} measures the relative share of the same group of workers in total hours in the firm. Similarly, equation 2.26 means the that the average hourly value added, $\overline{y}_j$, of workers of firm j is determined as

$$\begin{aligned} \ln \overline{y}_j &= \beta_0 + \ln[1 + (\delta_2 - 1) P_{21j} + (\delta_3 - 1) P_{31j} + (\delta_2 \delta_{22} - 1) P_{22j} \\ &\quad + (\delta_3 \delta_{32} - 1) P_{32j} + (\delta_3 \delta_{33} - 1) P_{33j} + \overline{\eta}^y_j] \end{aligned} \tag{30}$$

For the purpose of estimation, I shall approximate equations (2.29) and (2.30) by

$$\begin{aligned} \ln \overline{w}_j &= \alpha_0 + \ln[1 + (\lambda_2 - 1) P_{21j} + (\lambda_3 - 1) P_{31j} + (\lambda_2 \lambda_{22} - 1) P_{22j} \\ &\quad + (\lambda_3 \lambda_{32} - 1) P_{32j} + (\lambda_3 \lambda_{33} - 1) P_{33j}] + \overline{\eta}^w_j \end{aligned} \tag{31}$$

[8] This uses the first order Taylor series approximation $\exp x \approx 1 + x$.

and

$$\begin{aligned}\ln \overline{y}_j &= \beta_0 + \ln[1 + (\delta_2 - 1)P_{21j} + (\delta_3 - 1)P_{31j} + (\delta_2\delta_{22} - 1)P_{22j} \\ &\quad + (\delta_3\delta_{32} - 1)P_{32j} + (\delta_3\delta_{33} - 1)P_{33j}] + \overline{\eta}_j^y \qquad (32)\end{aligned}$$

respectively.

Although equation 2.32 is not estimable as it is, its parameters can be estimated since the conditional expectation of $\overline{y}_j$ enters the production function of j as the quality index of the firm's labour input. Suppose the production function is Cobb-Douglas[9] so that

$$E(Y_j|K_j, L_j) = AK_j^{\gamma_1}L_j^{\gamma_2} \qquad (33)$$

where, A, γ_1 and γ_2 are constants, Y_j is the value added of firm j, K_j is the corresponding capital input and L_j is the firm's input of quality adjusted hours. Let H_j be the firm's total input of unadjusted hours. I define L_j by

$$L_j = H_jE(\overline{y}_j|P_{21j}, P_{22j}, P_{31j}, P_{32j}, P_{33j}) \qquad (34)$$

Using 2.32, the average productivity of unadjusted hours, $\overline{Y}_j \equiv Y_j/H_j$, in the firm is then given by

$$\begin{aligned}\ln \overline{Y}_j &= \gamma_0 + \gamma_1 \ln\left(\frac{K_j}{H_j}\right) + (\gamma_1 + \gamma_2 - 1)\ln H_j + \gamma_2 \ln[1 + (\delta_2 - 1)P_{21j} + (\delta_3 - 1)P_{31j} \\ &\quad + (\delta_2\delta_{22} - 1)P_{22j} + (\delta_3\delta_{32} - 1)P_{32j} + (\delta_3\delta_{33} - 1)P_{33j}] + \xi_j \qquad (35)\end{aligned}$$

where $\gamma_0 = \ln A + \gamma_2\beta_0$ and ξ_j is a random error term including $\overline{\eta}_j^y$ as a component and, hence, generally correlated with $\overline{\eta}_j^w$ but assumed to be orthogonal to all regressors.[10]

The joint estimation of equations 2.31 and 2.35 is the basis for the testing of skill formation and job-matching effects in wage growth as will be reported

[9] The Cobb-Douglas specification is used in the empirical work to be reported in the next section since it could not be rejected against the translog. It should be noted that the basic arguments and derivations of this section are valid for any flexible functional form and are in no way dependent on the assumption of the Cobb-Douglas function.

[10] If the firm's labour input were homogenous, we would have $\beta_0 = 0$ and the experience and seniority profiles of productivity would both be flat so that $\delta_g = 1$ and $\delta_{gh} = 1$ for all g and h, in which case $E(\overline{y}_j|P_{21}, P_{22}, P_{31}, P_{32}, P_{33}) = 1$ and equation 7.35 would collaps to the usual specification whereby the conditional expectation of $\ln \overline{Y}_j$ is simply $\ln A + \gamma_1 \ln\left(\frac{K_j}{H_j}\right) + (\gamma_1 + \gamma_2 - 1)\ln H$.

in the next section.[11] In interpreting the average wage rate equation, it is important to note that α_0 is the log of the expected hourly wage of a worker at the lowest level of market experience and the lowest level of job-seniority, i.e., a worker for which $D^X_{1ij} = 1$ and $D^T_{1ij} = 1$. The parameter λ_g is the expected hourly wage of a worker at the lowest level of seniority and at experience level g relative the base wage e^{α_0}. The parameter λ_{gh} is the expected hourly wage of a worker at experience level g and job seniority level h relative to λ_g, where $1 < h \leq g$. Consequently, $\lambda_g\lambda_{gh}, 1 < h \leq g$ is the expected hourly wage of a worker at experience level g and seniority level h relative to the

[11] Hellerstein and Neumark(1995) derive wage and productivity equations of a similar form as 2.31 and 2.35 but for age categories of workers only and from the perspective of the firm rather than of the labour market as is done here. As should be evident from the discussion that follows it would be impossible to test the job-matching hypothesis on the basis of the age-profile of productivity unless it is estimated simultaneously with the job-seniority profile of the same. The derivation of the age profile of productivity as is done in the Hellerstein and Neumark paper is also problematic although it leads to the same functional form as used in this paper. The starting point in their approach is that the average productivity of hours in a firm is a weighted mean of the average productivity of hours of skill groups of workers just as the average hourly wage paid out by the firm is a weighed mean of hourly earnings of the same groups. The problem with viewing the average wage rate and average productivity of hours from the point of view of the firm rather than from that of its employees is that the economic meaning of the error term one then appends to the productivity or wage rate equation becomes unclear. In particular, one would not be able to motivate the inclusion of unobserved ability and job-match effects as components of the error term if, for example, one conceived of the dependent variable of the wage equation as the unit cost of labour to the firm rather than the average hourly earning of the firm's employees.

base wage, e^{α_0}.[12]

In interpreting equation 2.35 it is useful to note that

$$\begin{aligned} E(\overline{y}_j|P_{21j}, P_{22j}, P_{31j}, P_{32j}, P_{33j}) &= e^{\beta_0}[1 + (\delta_2 - 1)P_{21j} + (\delta_3 - 1)P_{31j} + (\delta_2\delta_{22} - 1)P_{22j} \\ &\quad +(\delta_3\delta_{32} - 1)P_{32j} + (\delta_3\delta_{33} - 1)P_{33j}] \end{aligned} \tag{36}$$

so that

$$L_j = e^{\beta_0}[H_{11j} + \delta_2 H_{21j} + \delta_3 H_{31j} + \delta_2\delta_{22} H_{22j} + \delta_3\delta_{32} H_{32j} + \delta_3\delta_{33} H_{33j}] \tag{37}$$

where H_{ghj} is the total number of hours of workers with experience level g and job-seniority level h. Let $Y_{jL} = \frac{\partial E(Y_j|K_j,L_j)}{\partial L_j}$. By substituting from equation 2.37 into equation 2.33, it can be seen that

$$\frac{\partial E(Y_j|K_j, L_j)}{\partial H_{11j}} = e^{\beta_0} Y_{jL}$$

while

$$\begin{aligned} \frac{\partial E(Y_j|K_j, L_j)}{\partial H_{g1j}} &= \delta_g e^{\beta_0} Y_{jL} \\ g &= 2, ..., G \end{aligned}$$

and

$$\begin{aligned} \frac{\partial E(Y_j|K_j, L_j)}{\partial H_{ghj}} &= \delta_g \delta_{gh} e^{\beta_0} Y_{jL} \\ g, h &= 2, ..., G \\ 1 &< h \leq g \end{aligned}$$

[12] To see this, note that we have from 2.31 that

$$E(\overline{w}_j/P_{21}, P_{22}, P_{31}, P_{32}, P_{33}) = e^{\alpha_0}[P_{11} + \lambda_2 P_{21} + \lambda_3 P_{31} + \lambda_2\lambda_{22}P_{22} + \lambda_3\lambda_{32}P_{32} + \lambda_3\lambda_{33}P_{33}]$$

where, P_{11} is the proportion of workers in the base group. Assuming that total annual hours, H_j, is fixed, the expected annual wage bill of the firm is

$$\begin{aligned} E(W_j/P_{21}, P_{22}, P_{31}, P_{32}, P_{33}) &\equiv H_j E(\overline{w}_j/P_{21}, P_{22}, P_{31}, P_{32}, P_{33}) \\ &\equiv e^{\alpha_0}[H_{11} + \lambda_2 H_{21} + \lambda_3 H_{31} + \lambda_2\lambda_{22} H_{22} + \lambda_3\lambda_{32} H_{32} + \lambda_3\lambda_{33} H_{33}] \end{aligned}$$

Let W_{j11} be the annual wage bill on workers in the base group, W_{jg} the annual wage bill of workers at experience level g and seniority level one and W_{jgh} the annual wage bill on workers at experience level g and seniority level h with $g = 2, 3$ and $1 < h < g$. Then $E(W_{j11}/P_{21}, P_{22}, P_{31}, P_{32}, P_{33}) = e^{\alpha_0} H_{11}$, $E(W_{jg}/P_{21}, P_{22}, P_{31}, P_{32}, P_{33}) = \lambda_g e^{\alpha_0} H_{g1}$ and $E(W_{jgh}/P_{21}, P_{22}, P_{31}, P_{32}, P_{33}) = \lambda_{gh}\lambda_g e^{\alpha_0} H_{gh}$. Consequently, the expected hourly wage is e^{α_0} for workers in the base group, $\lambda_g e^{\alpha_0}$ for workers at experience level g and seniority level one and $\lambda_{gh}\lambda_g e^{\alpha_0}$ for workers at experience level g and seniority level h.

The parameter δ_g is therefore the expected marginal product of a worker with the lowest level of seniority at experience level g relative to the expected marginal product of a worker in the base group. The expected marginal productivity of a worker at experience level g and seniority level h relative to a worker with the lowest level of seniority but at the same level of experience is given by δ_{gh}, while $\delta_g\delta_{gh}$ is the same expected marginal product but relative to the expected marginal product of a worker in the base group.

2.2 Testing for Skill Formation and Job Matching Effects in Wage Growth

The experience and job seniority profiles of relative wages as captured by equation 2.31 can usefully be summarised into an experience-seniority 'profile matrix' in which each row describes the job seniority profile of the expected wage rate, relative to the base, of a worker at a given level of market experience and a column describes the experience profile of the expected relative wage of a worker at a given level of job-seniority:

$$
\begin{array}{lllll}
1.00 & & & & \\
\lambda_2 & \lambda_2\lambda_{22} & & & \\
\lambda_3 & \lambda_3\lambda_{32} & \lambda_3\lambda_{33} & & \\
. & . & . & & \\
. & . & . & & \\
. & . & . & & \\
\lambda_G & \lambda_G\lambda_{G2} & \lambda_G\lambda_{G3} & \ldots & \lambda_G\lambda_{GG}
\end{array}
$$

The corresponding experience-seniority profile matrix of relative marginal productivity as read from equation 2.35 is

$$
\begin{array}{lllll}
1.00 & & & & \\
\delta_2 & \delta_2\delta_{22} & & & \\
\delta_3 & \delta_3\delta_{32} & \delta_3\delta_{33} & & \\
. & . & . & & \\
. & . & . & & \\
. & . & . & & \\
\delta_G & \delta_G\delta_{G2} & \delta_G\delta_{G3} & \ldots & \delta_G\delta_{GG}
\end{array}
$$

Of particular interest in each matrix are the diagonal entries and entries of the first column. The former map out the life cycle growth of the expected relative wage rate or relative marginal product of a non-mobile worker, that is, a worker who has never changed his job after the first k_1 years of time in the labour market, where k_1 is the maximum number years in the labour market of a worker in the base group. The first column describes the life cycle growth of the expected relative wage or relative marginal product of a fully mobile worker, that is, a worker who changes his job at least every k_1 years. In other words, the first column is a description of the between-jobs growth of the relative wage rate or relative marginal product with time in the labour market. Consequently it captures the pure effect of market experience on the wage rate or marginal productivity. On the other hand, the diagonal of the matrix is a description of the within-job growth of the relative wage rate or relative marginal product with experience and, therefore, captures the sum of the effect of market experience and the effect of job-seniority.esting For General Skill-Formation

A rising experience profile of wages implies that λ_g increases with g at least initially. According to existing theory this is indicative of one or more of three things, namely, on-the-job general skill formation, match improvement and deferment of compensation as an insurance, screening or disciplining device. However, current theories of deferred compensation do not predict a rising profile of relative marginal productivity while both the job matching hypothesis and the theory of human capital do. Observation that both λ_g and δ_g increase with g at least initially is therefore evidence that not all the observed between-jobs growth can be attributed entirely to deferment of compensation. Assuming that we do have evidence for skill formation or job-matching in this sense, the question then arises whether we can exclude the possibility that the observed between-jobs growth in *productivity* is entirely a job-matching effect. The null that all the observed between- jobs growth of productivity is a mobility gain can be tested by comparing the estimated experience profile of relative marginal productivity with that of the relative wage since on-the-job search or matching cannot, on its own, create a discrepancy between spot wage and spot marginal productivity while the general skill formation hypothesis does. Specifically, we reject the same null if we observe that $\lambda_g < \delta_g$ in the rising phase of the profile of marginal productivity since the inequality is consistent with the implication of human capital theory that on-the-job investment on general skills is wholly financed by the worker.[13]

[13]While λ_g and δ_g, respectively, are the expected relative wage and expected relative marginal product of a worker at experience level g, we have $\lambda_g < \delta_g$ only if the expected absolute wage of the worker is less than his expected absolute marginal product. Likewise $\lambda_g = \delta_g$ only if the expected absolute wage is equal to the expected absolute marginal

2.2.1 Testing For Mobility Gains

Assume next that we have observed that both λ_g and δ_g rise at least initially and that $\lambda_g < \delta_g$ in the rising phase of the experience profile of marginal productivity. This will leave us with the other extreme possibility open, namely, that there are no productivity gains from mobility so that the observed between-jobs growth in productivity should be attributed entirely to skill formation. One way of testing this as a null is to compare the between-jobs experience profile of marginal productivity with the corresponding within-job profile, i.e., to compare the first column entries of the profile matrix of marginal productivity with the corresponding diagonal entries of the same matrix. Recall that the expected relative marginal product of a non-mobile worker at experience level g is $\delta_g\delta_{gg} = 1 + \beta^s_g + \beta^s_{gg} + b^\phi_{gg} + b^\mu_{gg}$. On the other hand, $\delta_g = 1 + \beta^s_g + b^\phi_g$ so that $\delta_g\delta_{gg} - \delta_g = \beta^s_{gg} + b^\phi_{gg} + b^\mu_{gg} - b^\phi_g$. Since $\beta^s_{gg} + b^\mu_{gg} \geq 0$, we have $\delta_g\delta_{gg} < \delta_g$ only if $b^\phi_g - b^\phi_{gg} > 0$, that is, only if there is a positive job mathing effect. Consequently, observation that $\delta_g\delta_{gg} < \delta_g$ is evidence that not all the observed between-jobs growth of marginal productivity can be attributed to skill formation. Unfortunately, observation to the contrary that $\delta_g\delta_{gg} \geq \delta_g$ does not necessarily imply the absence of a job matching effect since the same observation can occur despite a positive matching effect if $\beta^s_{gg} + b^\mu_{gg} > b^\phi_g - b^\phi_{gg}$. A more discriminating test is to compare the expected relative marginal product of a fully mobile worker with that of a worker with the same level of market experience, but in an intermediate state of mobility, that is, to compare δ_g with $\delta_g\delta_{gh}$ where $1 < h < g$ rather than with $\delta_g\delta_{gg}$. This is because we expect $\beta^s_{gh} + b^\mu_{gh}$ to be smaller than $\beta^s_{gg} + b^\mu_{gg}$ for $1 < h < g$. We have $\delta_g\delta_{gh} = 1 + \beta^s_g + \beta^s_{gh} + b^\mu_{gh} + b^{\phi h}_g + b^\phi_{gh}$ so that $\delta_g\delta_{gh} - \delta_g = \beta^s_{gh} + b^\mu_{gh} + b^{\phi h}_g + b^\phi_{gh} - b^\phi_g$. Since $\beta^s_{gh} + b^\mu_{gh} \geq 0$, this means that we observe $\delta_g\delta_{gh} < \delta_g$ only if $b^\phi_g - (b^{\phi h}_g + b^\phi_{gh}) > 0$, i.e., only if $b^\phi_g > (b^{\phi h}_g + b^\phi_{gh})$, which, under the implication $b^{\phi h}_g + b^\phi_{gh} > 0$ of Topel's search and match technology, means that $b^\phi_g > 0$, i.e., mobility gains are positive.

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product. To see this we need only note that the expected wage and the expected marginal product of a woker in the base group are e^{α_0} and e^{β_0} respectively. The expected wage rate of a worker at experience level g and seniority level one is $e^{\alpha_0+\alpha_{1g}}$ while the expected marginal product of the same worker is $e^{\beta_0+\beta_{1g}}$. Since the definitions of λ_g and δ_g are $\lambda_g = \frac{e^{\alpha_0+\alpha_{1g}}}{e^{\alpha_0}}$ and $\delta_g = \frac{e^{\beta_0+\beta_{1g}}}{e^{\beta_0}}$, we have $\frac{\delta_g}{\lambda_g} = e^{\beta_{1g}-\alpha_{1g}}$, that is, $\lambda_g < \delta_g$ only if $\beta_{1g} > \alpha_{1g}$.

2.2.2 Testing For Specific Skill Formation

If the mobility gain b_g^{ϕ} is positive, so that $\delta_g \delta_{gh} < \delta_g$, we must also have $\delta_{gh} < 1$, that is, the expected marginal product of a worker at experience level g and job-seniority level h, where $1 < h < g$, must be less than the marginal product of a newly matched worker at the same level of market experience. Note also that

$$\begin{aligned} \delta_{gh} &= 1 + \left(\frac{\beta_{gh}^{s} + b_{gh}^{\mu} + b_g^{\phi h} + b_{gh}^{\phi} - b_g^{\phi}}{\delta_g} \right) \\ h &< g, g = 2, ..., G \end{aligned} \tag{38}$$

On the other hand, since $b_g^{\phi g} = 0$, we have

$$\begin{aligned} \delta_{gg} &= 1 + \left(\frac{\beta_{gg}^{s} + b_{gg}^{\phi} + b_{gg}^{\mu} - b_g^{\phi}}{\delta_g} \right) \\ g &= 2, ..., G \end{aligned} \tag{39}$$

A rising job-seniority profile of relative marginal productivity means that δ_{gh} increases with h initially and is non-decreasing thereafter, i.e.,

$$1 > \delta_{g2} < \delta_{gh} \leq \delta_{gg} \tag{40}$$

for all $h : 2 < h < g$ so that the series $1, \delta_{g2}, ..., \delta_{gh}, ..., \delta_{gg}$ maps out a U-shape. In view of equation 2.38, observation $\delta_{gh} < 1$ is evidence that δ_{gh} understates the true effect of job-seniority on marginal productivity as the result of the mobility gains, b_g^{ϕ}, at experience level g .This follows from the fact that $\beta_{gh}^{s} + b_{gh}^{\mu} \geq 0$ so that the observation is possible only if $b_g^{\phi h} + b_{gh}^{\phi} - b_g^{\phi} < 0$. This in turn is possible only if $b_g^{\phi} > 0$ under the job-matching hypothesis that $b_g^{\phi h} + b_{gh}^{\phi} > 0$. In view of equation 2.39, observation that $\delta_{gg} > 1$ is evidence that, on average, a more senior worker on a job is more productive, i.e., $\beta_{gg}^{s} + b_{gg}^{\mu} > 0$, as long as the implication of Topel's match technology that $b_{gg}^{\phi} < 0$ is valid so that $b_{gg}^{\phi} - b_g^{\phi} < 0$. Moreover,as $h \dashrightarrow g$, $b_g^{\phi h} \dashrightarrow 0$ while b_{gh}^{ϕ} decreases so that net mobility gains, $b_g^{\phi h} + b_{gh}^{\phi}$, and $b_g^{\phi h} + b_{gh}^{\phi} - b_g^{\phi}$ both decrease. A rising job-seniority profile of marginal productivity in the sense of equation 7.40 is therefore evidence that $\beta_{gh}^{s} + b_{gh}^{\mu}$ rises with seniority. It is of course possible that $\beta_{gh}^{s} = 0$ for all $g, h : 2 \leq h \leq g$ so that none of the observed growth in marginal productivity can be attributed to specific skill formation.

This is a null which we can test by comparing the observed job-seniority of profile of relative marginal productivity with the corresponding job-seniority profile of relative wages, that is, by comparing the series $1, \delta_{g2}, ..., \delta_{gh}, ..., \delta_{gg}$ with the series $1, \lambda_{g2}, ..., \lambda_{gh}, ..., \lambda_{gg}$. First, if specific skill formation or job-matching effects are the main determinants of both λ_{gh} and δ_{gh} the job seniority profile of relative wages should also exhibit the same U-shape that the job-seniority profile relative marginal productivity does, since we have

$$\begin{aligned} \lambda_{gh} &= 1 + \left(\frac{\alpha^{s}_{gh} + a^{\mu}_{gh} + a^{\phi h}_{g} + a^{\phi}_{gh} - a^{\phi}_{g}}{\lambda_{g}} \right) \\ h &< g, g = 2, ..., G \end{aligned}$$

corresponding to equation 2.38 and

$$\begin{aligned} \lambda_{gg} &= 1 + \left(\frac{\alpha^{s}_{gg} + a^{\phi}_{gg} + a^{\mu}_{gg} - a^{\phi}_{g}}{\lambda_{g}} \right) \\ h &< g, g = 2, ..., G \end{aligned}$$

corresponding to 2.39. Given that both job-seniority profiles are U-shaped, the null should be rejected if we observe $\lambda_{gh} > \delta_{gh}$ in the rising phase of seniority profile of marginal productivity and $\lambda_{gh} < \delta_{gh}$ thereafter, since this will be indicative of the sharing of the cost of specific skill formation by the firm and the worker as is the prediction of the specific capital hypothesis.

2.3 Measuring the Relative Magnitudes of Skill Formation and Mobility Effects

The joint estimation of equations 2.31 and 2.35 thus enables us to test for both skill formation and mobility effects even in a single cross-section of observations. However, we need to estimate the equations in first difference or error component versions if we are to proceed beyond this and obtain an estimate of the magnitude of either effect. Unfortunately the sample size of firms per time period is too small for me to pursue this route in this study. Instead I have taken advantage of the availability of a three-year panel of observations on earnings and related characteristics of workers randomly sampled from the firms for which equations 2.31 and 2.35 have been estimated. An earnings function analysis of this additional piece of information is useful in two ways. First, it provides a conventional benchmark against which results of estimation of firm level average productivity and average wage rate equations can be viewed. Secondly, it can give us some idea of the magnitude of mobility effects relative to the effect of skill formation, if and when the existence of both is established by the analysis of firm level productivity and wage data.

To see this, suppose equations 2.1 applies to longitudinal observations so that we should in fact write:

$$\ln w_{ijt} = X_{1ijt}\alpha_1^s + X_{2ijt}\alpha_2^s + \epsilon_{ijt}^w \tag{41}$$

where

$$\epsilon_{ijt}^w = \phi_{ij}^w + \mu_i^w + \nu_{ijt}^w$$

and distributional assumptions about error components are as stated before. Topel (1991) has proposed a two-step IV procedure for obtaining a consistent estimate of a lower bound for the true effect, α_2^s, of job seniority on wages using data on within-job growth of earnings. The first step of the procedure is the application of OLS to the first difference of 2.41, which results in a consistent estimate, $\widehat{A} \equiv \widehat{\alpha_1^s + \alpha_2^s}$, of $\alpha_1^s + \alpha_2^s$. The second step consists in obtaining IV estimates, $\widehat{\alpha}_1^{IV}$ and $\widehat{\alpha}_2^{IV}$, of α_1^s and α_2^s respectively by applying least squares to

$$\begin{aligned} \ln w - X_2\widehat{A} &= X_1^0\alpha_1^s + X_2\left(a_1^\phi + a_2^\phi\right) + e_1 \\ \ln w - X_1\widehat{A} &= -X_1^0\alpha_2^s + e_2 \end{aligned} \tag{42}$$

with X_1 as an instrument for X_1^0 in the estimation of each equation.[14] It can be shown that

$$\begin{aligned} E\widehat{\alpha}_1^{IV} &= \alpha_1^s + a_1^\phi + \frac{\gamma_{12}}{1-\gamma_{12}}\left(a_1^\phi + a_2^\phi\right) \\ E\widehat{\alpha}_2^{IV} &= \alpha_2^s - a_1^\phi - \frac{\gamma_{12}}{1-\gamma_{12}}\left(a_1^\phi + a_2^\phi\right) \end{aligned} \tag{43}$$

where γ_{12} is the coefficient of the regression of X_2 on X_1. I will exploit two features of Topel's procedure for the purpose at hand. First, the procedure consistently estimates the net mobility gain parameter $a_1^\phi + a_2^\phi$. Secondly, although $\widehat{\alpha}_1^{IV}$ and $\widehat{\alpha}_2^{IV}$ are biased for their respective parameters, $\widehat{\alpha}_1^{IV}$ is

[14]The terms e_1 and e_2 are random errors respectively given by $\epsilon^w + X_2(A - \widehat{A})$ and $\epsilon^w + X_1(A - \widehat{A})$, where, $A = a_1^\phi + a_2^\phi$.

biased up for α_1^s exactly by the same amount that $\widehat{\alpha}_2^{IV}$ is biased down for α_2^s. For given values of $\widehat{\alpha}_1^{IV}$ and $\widehat{\alpha}_2^{IV}$ we can calculate $\widehat{\lambda}_g^{IV}$, $\widehat{\lambda}_{gg}^{IV}$ and $\widehat{\lambda}_g^{IV}\widehat{\lambda}_{gg}^{IV}$ as our estimates of λ_g, λ_{gg} and $\lambda_g\lambda_{gg}$ respectively, which, in view of 7.43, have the properties

$$E\widehat{\lambda}_g^{IV} = 1 + \alpha_g^s + a_g^\phi + \frac{\gamma_{12}}{1-\gamma_{12}}\left(a_g^\phi + a_{gg}^\phi\right) \tag{44}$$

$$E\widehat{\lambda}_{gg}^{IV} = 1 + \alpha_{gg}^s - a_g^\phi - \frac{\gamma_{12}}{1-\gamma_{12}}\left(a_g^\phi + a_{gg}^\phi\right) \tag{45}$$

and

$$E\widehat{\lambda}_g^{IV}\widehat{\lambda}_{gg}^{IV} = 1 + \alpha_g^s + \alpha_{gg}^s \tag{46}$$

By using $\widetilde{\alpha}_1 = \widehat{\alpha}_1^{IV} - \frac{\widehat{\gamma}_{12}}{1-\widehat{\gamma}_{12}}\left(\widehat{a_g^\phi + a_{gg}^\phi}\right)$ instead of $\widehat{\alpha}_1^{IV}$ we can also calculate an alternative estimator, $\widetilde{\lambda}_g$, of λ_g with the property that

$$E\widetilde{\lambda}_g = 1 + \alpha_g^s + a_g^\phi \tag{47}$$

Clearly, $\widehat{\lambda}_g^{IV}\widehat{\lambda}_{gg}^{IV}$ is consistent for the sum of the true return to market experience and the true return to job-seniority. Hence it is consistent for an upper bound of the true return to market experience. It is also clear that $(\widehat{\lambda}_g^{IV} - \widetilde{\lambda}_g)/(\widehat{\gamma}_{12}/1-\widehat{\gamma}_{12})$ is consistent for $a_g^\phi + a_{gg}^\phi$. Consequently, the ratio of $(\widehat{\lambda}_g^{IV} - \widetilde{\lambda}_g)/(\widehat{\gamma}_{12}/1-\widehat{\gamma}_{12})$ to $\widehat{\lambda}_g^{IV}\widehat{\lambda}_{gg}^{IV} - 1$ is consistent for the ratio of net mobility gains,$a_g^\phi + a_{gg}^\phi$, to the sum of the true returns to experience and job seniority, $\alpha_g^s + \alpha_{gg}^s$ and, hence, for a lower bound of the ratio of net mobility gains to the return to general skill formation in the between-jobs growth of wages. Read in conjunction with the results of the estimation of equations 2.31 and 2.35, this should give us some idea of the ratio of net mobility gains to the return to general skill formation in the between -jobs growth of marginal productivity with market experience.

3 Data and Results

3.1 Data

The paper is based on the 1993 and 1995 waves of the Addis Ababa Industrial Enterprise Survey (AAIES). The 1993 wave of the survey covered a random selection of 220 manufacturing establishements in the the Adddis Ababa region of Ethiopia, of which 30 were public enterprises. The 1995 wave revisited all the public enterprises and 164 of privately owned firms surveyed in the 1993 wave and an additional 26 private firms as replacement to those which exited the sample by 1995. Each wave involved the administration of a written questionnaire to enterprise managers in several modules and a separate labour market module to a random selection of workers from each firm. The data analysed here were drawn from returns to the production and labour market modules of the questionnaire to managers in both waves, and the labour maket questionnaire to workers in the 1995 wave.

It is possible that most on-the-job skill formation in firms sampled for the survey is due to learning-by-doing. However, it is also clear that both firms and workers actively invest in skills through apprenticeship programmes and post-apprenticeship training schemes. Typically, a new recruit with no prior work experience joins a firm under an apprenticeship programme lasting for about a year. For instance, some 38 per cent of employees of private firms covered in the 1995 wave had passed through or were undergoing such a programme in the present firm. Another 22 per cent had done their apprenticeship in other firms but within the same industry (Table 3.1). The proportion of workers who have had their apprenticeship with the present employer naturally decreases as we move up age groups from about 47 per cent within the 0-5 year experience group to about 30 per cent for those 16 years or more of experience. Correspondingly the proportion of those who had their apprenticeship elsewhere in the same industry rises with time in the labour market from about 11 per cent for the 0-5 year experience group to less than 29 per cent for those with 16 years or more of market experience. At the time of the 1993 wave, about 13 per cent of workers in private firms were undergoing post-apprenticeship on-the-job training. The incidence of current on-the-job training decreases with age from 20 per cent for those with five years or less of time in the labour market to about 8 per cent for those with 16 years or more of market experience.

The survey also shows that employers and workers use a variety of formal and informal channels to gather and disseminate information in the job matching process. By formal channels I mean official advertisement of jobs and the registration of vacancies and workers' availability through employment agencies. Employers are resorting to informal channels when they use 'business associates', current employees or 'friends and relatives' as informants or referees. Door-to-door inquiry for vacancies and the use of friends or relatives as sources of information on the same are all instances of the use

Table 1: On-the-job Active Training, Private Sector Workers, AAIES, 1993.

	Market Experience in years				All workers
	0-5	6-10	11-15	16 +	
Per cent of workers who have had apprenticeship with the current employer	46.7	40.5	42.6	29.8	37.9
Per cent of workers who have had apprenticeship in another firm in the same industry	10.8	18.2	24.2	28.6	21.6
Per cent of workers who are being trained in the the current firm	20.1	15.9	13.4	7.6	13.5
Number of workers	213	245	194	340	992

of informal channels by job seekers. Although the range of available channels is thus similar to that found in the developed world, the survey also shows that the use of formal channels in Ethiopia is restricted almost entirely to the public sector. This can be seen from Tables 3.2 and 3.3. Asked to specify the most common way of finding new workers, less than 5 per cent of privately owned firms covered in the 1993 wave cited official advertising or the use of employment agencies against a corresponding figure of 93 per cent for public enterprises (Table 3.2). About 55 per cent of private firms identified relatives, friends or business associates as the most common source of information on new workers while another 36 per cent identified current employees as the most common source. In response to the question as to how a worker first came to know about his/her current job, less than 4 per cent of private secotr workers in 1995 sample cited formal channels against a corresponding figure of 88 per cent for public enterprise employees. About 43 per cent of private sector workers said that they first heard about the current job from own relatives or friends. Another 21 per cent were tipped off by friends or relatives of the owner of the firm. Some 32 per cent discovered the job in the course of door-to-door search or heard about it 'by word of mouth'. In contrast,

Table 2: Distribution of Firms by the Most Common Way of Finding Workers, AAIES, 1993

Most common way of finding workers	Private Firms		Public Enterprises	
	Number	%	Number	%
Relatives, friends or associates of the owner	102	54.8	-	-
Employees	66	35.5	2	6.6
Official advertisement	6	3.2	12	40.0
Employment Office	2	1.1	16	53.4
Other	10	5.4	-	-
Total	186	100.0	30	100.0

informal channels provided first information on the current job for only 7 per cent of public sector workers. The figure for the proportion of private sector job seekers who use formal channels is extremely low compared to what is observed in developed economies. For instance, a survey of search methods by unemployed youth in the United States in the early 1980s revealed that about 58 per cent of them consulted newspaper ads while 54 per cent used public employment agencies (Holzer, 1988). On the other hand, it should be noted that the same US survey also showed that the proportion of job seekers who used informal sources was also almost as high as the Ethiopian figure for job-seekers in the private sector: some 85 per cent of the US respondents reported to have used friends or relatives as sources of information.

Equations 2.31 and 2.35 were estimated on the basis of 345 observations on privately owned establishments pooled from the two waves. A firm was included in this sample only if it met two criteria, namely, that it was privately owned and that complete observations were available on the firm from the 1995 wave. This meant that a 1993 observation was included in the pool only if it was complete and related to a privately owned firm on which complete observations were available from the 1995 wave. Public enterprises have been excluded from the sample analysed here because of the evidence that public sector jobs in Ethiopia are rationed and the apparent difference in the job-matching process between the public and private sectors. Earnings function estimates are based on observations on 1448 of the workers covered by the 1995 wave. The sample selection criterion used here was that an observation

Table 3: Distribution of Sample Workers by Source of First Piece of Infromation About the Current Job, AAIES, 1995-wave.

How did you first hear about your current job?	Private sector workers		Public sector workers	
	Number	Per cent	Number	Per cent
From relatives or friends of mine	576	42.5	7	2.3
From relatives or friends of the firm owner	279	20.6	-	-
By word of mouth	223	16.5	15	5.0
I went door to door	207	15.3	9	3.0
Through an official advertisement	39	2.9	44	14.7
Through the Employment Office	3	0.2	219	73
Other	27	0.2	219	73.0
Total	1354	100.0	300	100.0

related only to a worker who had been continuously employed for at least three years by 1995 in a firm belonging to the sample used to estimate equations 2.31 and 2.35. The requirement of a minimum of three-year continuous employment on the same job is the only way of ensuring that earnings function estimates are not contaminated by earnings data from past employment in firms outside of the sample used to estimate the productivity and wage equations.

For the purpose of estimation, equation 2.35 has been augmented to include dummy variables as controls for variation in year of observation, composition of work force by level of schooling, gender composition of the work force, employment size of the firm, age of the firm, average age of equipment, main method of production and industry. With the exception of those relating to the age of the firm and the average age of its equipment, the same dummy variables also figure in the estimated version of equation 2.31. Definitions of these and basic variables of the two equations are given in Table 3.5 along with descriptive statistics. Output, wage and capital stock figures for 1993-observations were all expressed at 1995 prices using the Addis Ababa Retail Price Index before pooling observations across the two waves of the

Table 4: Mean and Standard Deviations of Shares of Experience-Seniority Cells in Annual Labour Input.

(Standard deviations in parentheses)

Experience (years)	Job Seniority (years) 0-5	6-10	11-15	16+	Row sum
0-5	0.1821 (0.2271)				0.1821
6-10	0.1840 (0.2161)	0.0642 (0.1131)			0.2482
11-15	0.1044 (0.1570)	0.0411 (0.0864)	0.0262 (0.0796)		0.1717
16+	0.1776 (0.2211)	0.0643 (0.1140)	0.0429 (0.0961)	0.1102 (0.2184)	0.3950
Col. sum	0.6481	0.1696	0.0691	0.1102	

survey. Output is defined as annual production less the value of intermediate inputs and utility charges. The corresponding annual capital input is proxied by the estimated current sales value of equipment at 1995 prices. Time in the labour market or potential experience is measured as age expressed to the nearest year minus years of schooling minus six. Job seniority is measured as the nearest full number of continuous years of employment in the current firm. Experience-seniority cells of the work force of a firm are defined in terms of four levels or year intervals, namely, 5 years or less, 6 to 10 years, 11 to 15 years and 16 years or over. The base cell consists of workers with 5 years or less of potential market experience. The share of an experience-seniority cell of workers in the annual input of labour in a firm is defined as the ratio of annual hours of workers in the cell to total annual hours of all workers in the firm. Descriptive statistics for shares of individual cells are given in Table 3.4.

Table 3.6 gives descriptive statistics and definitions of variables used in the estimation of earnings functions. Earnings function estimates in levels refer to 1994 and 1995 observations for workers employed continuously in the current firm for at least the past three years. Earnings function estimates in first difference are based on the difference between 1995 hourly wages for the same workers and their 1994 hourly wages, the latter having first been expressed at 1995 prices. The control dummies used in the estimation of earning functions

Table 5: Descriptive Statistics For Variables In Firm Level Productivity and Wage Equations

Variable	Variable Definition	Mean	S.D
WAGE	Log wage bill per man hour	0.4891	1.1796
OUTPUT	Log output per man hour	1.2589	1.2091
CAPITAL	Log capital stock per man hour	1.6570	1.6646
HOURS	Log annual hours	10.13	0.9494
SIZE2	Dummy=1 if employment size is 11-20 workers	0.21	0.41
SIZE3	Dummy=1 if employment size is 21-50 workers	0.16	0.36
SIZE4	Dummy=1 if employment size is 51-100 workers	0.06	0.25
SIZE5	Dummy=1 if employment size is more than 100	0.04	0.12
AGE2	Dummy=1 if the age of the frim is 5-10 years	0.13	0.33
AGE3	Dummy=1 if the age of the firm is 11-20 years	0.28	0.45
AGE4	Dummy=1 if the age of the firm is more than 20 years	0.26	0.44
EQAGE2	Dummy=1 if the average age of equipment is 6-10 years	0.21	0.41
EQAGE3	Dummy=1 if the average age of equipment is 11-15 years	0.15	0.36
EQAGE4	Dummy=1 if the mean age of equipment exceeds 15 yrs	0.21	0.41
CRAFT	Dummy=1 if the main method of production is craft work.	0.18	0.39
BATCH	Dummy=1 if the main method of production is batch mode.	0.08	0.28
TEAM	Dummy=1 if the main method of production is team work	0.31	0.47
DPRIM	Dummy=1 if more than 90% of employees have completed primary school	0.72	0.45
DSEC	Dummy=1 if more than 58% of employees have completed secondary school	0.47	0.50
DVOC	Dummy=1 if the firm employs at least one graduate of a vocational college	0.13	0.34
PROFEM2	Dummy=1 if a tenth to a quarter of employees are female	0.29	0.45
PROFEM3	Dummy=1 if a quarter to a half of employees are female	0.33	0.47
PROFEM4	Dummy=1 if more than half of employees are female	0.11	0.32
1995	Dummy=1 for a 1995 observation	053	0.50
TEXT	Dummy=1 for textiles firms	0.07	0.25
GARM	Dummy=1 for garment producing firms	0.16	0.37
KNIT	Dummy=1 for knitwear producer	0.12	0.33
LEATH	Dummy=1 for leather products	0.15	0.36
WOOD	Dummy=1 for furniture and wood workd	0.12	0.33

Table 6: Descriptive Statistics For Variables in Earnings Functions

Variables	Definition	Mean	S.D
LNRWAGE	Log hourly wage at 1995 prices	0.40770	0.7818
ΔLNRWAGE	Annual change in LNRWAGE	0.0047	0.2418
EXPR	Potential market experience in years	18.698	14.402
EXPRSQ/10^2	EXPR squared/10^2	5.569	8.587
EXPRCB/10^3	EXPR cubed/10^3	21.720	46.945
EXPRQR/10^4	EXPR raised to the 4th power/10^4	98.835	283.565
TENURE	Number of years on the current job	8.587	7.975
TENURESQ/10^2	TENURE squared/10^2	1.376	2.778
TENURECB/10^3	TENURE cubed/10^3	3.258	10.428
TENUREQR/10^4	TENURE raised to the 4th power/10^4	95.969	43.299
ΔEXPRSQ/10^2	annual change in EXPRSQ/10^2	0.403	0.373
ΔEXPRCB/10^3	annual change in EXPRCB/10^3	1.693	2.495
ΔEXPRQR/10^4	annual change in EXPRQR/10^4	8.547	18.376
ΔTENURESQ/10^2	annual change in TENURESQ/10^2	0.166	0.160
ΔTENURECB/10^3	annual change in TENURECB/10^3	0.398	0.814
ΔTENUREQR/10^4	annual change in TENUREQR/10^4	1.254	4.025
EDUC1	Dummy=1 if highest level of education completed is primary	0.36	0.48
EDUC2	Dummy=1 if highest level of education completed is secondary	0.38	0.49
EDUC3	Dummy=1 if have had tertiary education	0.10	0.10
SIZE295	Dummy=1 for employer size in 1995 was 11-20 workers	0.22	0.41
SIZE395	Dummy=1 if employer size in 1995 was 21-50 workers	0.26	0.44
SIZE495	Dummy=1 if employer size in 1995 was 51-100 workers	0.27	0.44
SIZE595	Dummy=1 if employer size in 1995 was more than 100 workers	0.16	0.37
FEMALE	Dummy=1 if female	0.23	0.42

in levels relate to schooling, gender, industry and employment size.

3.2 Results

3.2.1 Profile Matrices of Relative Marginal Productivity and Relative Wages

Non-linear SUR estimates of the firm level average productivity and wage rate equations are reported in Table 3.7. The productivity equation is estimated based on the Cobb-Douglas specification. Parameters of the relative marginal productivity equation can be derived and estimated for any flexible specification of the production function of the firm including the translog. However, based on the estimation of the equivalent of equation 2.35 under the translog specification, a Wald test could not reject the Cobb-Douglas restrictions at a reasonable level of significance (p-value=0.4214). Estimates of coefficients of control variables, namely, year of observation, schooling, industry, firm size, firm age, average age of equipment and mode of production are reported in the Appendix. In Tables 3.8 and 3.9, I report the experience-seniority profile matrices of relative marginal productivity and relative wages as read from Table 3.7. P-values of Wald tests of within and cross-equation restrictions of interest relating to the profiles of marginal productivity and wages are reported in Table 3.10.

In Table 3.8, each element is an estimate of the expected wage rate of a worker of a given level of market experience and a given level of job seniority relative to the expected wage rate of a worker in the base group, that is, a worker for whom market experience is five years at most. The corresponding entry in Table 3.9 estimates the expected marginal product of a worker in the same experience-seniority group relative to the expected marginal product of a worker in the base group. In either table, a column shows how the expected relative marginal product or relative wage changes as market experience rises from one 5-year level to the next assuming that job seniority is always fixed at some 5-year level. A row describes how the expected relative marginal product or the expected relative wage changes as job-seniority increases from one 5-year level to the next but, this time, assuming that market experience is fixed at some 5-year level. The first column maps out the estimated between-jobs experience profile of expected relative marginal productivity or wages for a fully mobile worker, that is, a worker who changes jobs at least once every five years. Diagonal elements estimate the corresponding within-job

Table 7: Non-linear SUR Estimates of the Structural Parameters of the Average Wage and Average Producitvity Equations.

	Average Hourly Wage Equation	Average Hourly Productivity Equation
Base Relative Wage, λ_g,		
or Relative Marginal Product, δ_g,		
Experience level: 6-10 years	1.3203	1.6486
	(0.32899)	(0.44986)
11-15 years	1.3568	2.2532
	(0.32106)	(0.46532)
16 years or more	1.7545	1.7882
	(0.45869)	(0.58717)
Relative Wage, λ_{gh}, or Relative		
Marginal Product, δ_{gh}, of Seniority Groups		
Experience 6-10 years		
Seniority Level		
6-10 years	0.7830	0.8107
	(0.66027)	(0.73586)
Experience 11-15 years		
Seniority Level		
6-10 years	0.7744	0.2605
	(0.53457)	(0.34611)
11-15 years	1.7128	1.0696
	(0.80443)	(0.65347)
Experience 16 years or more		
Seniority Level		
6-10 years	0.8950	-0.0829
	(0.58958)	(0.54117)
11-15 years	1.1317	0.2663
	(0.94720)	(0.57673)
16 or more years	1.3822	1.5393
	(0.51433)	(0.73830)
CAPITAL		0.0992
		(0.02546)
HOURS		-0.0692
		(0.01377)
Constant	-0.4602	1.4087
	(0.33772)	(1.0019)

Note: Standard errors in parentheses.

Table 8: Estimated Experience-Seniority Profile Matrix of Relative Wages

	LEVELS OF JOB SENIORITY			
		$\lambda_g\lambda_{gh}$		
EXPERIENCE:	5 years or less (λ_g)	6-10 years	11-15 years	16 years or more
5 years or less	1.0000			
6-10 years	1.3203 (0.32899)	1.0338 (0.79645)		
11-15 years	1.3568 (0.32106)	1.0508 (0.67289)	2.3240 (0.9495)	
16 years or more	1.7545 (0.45869)	1.5702 (0.9464)	1.9856 (1.5454)	2.4252 (0.6246)

Note: Standard errors in parentheses.

growth since they refer to a non-mobile worker, i.e., a worker who has never changed his job since his first five years in the labour market. Off diagonal elements other than those in the first column estimate the expected relative marginal product or wage of a worker in an intermediate state of mobility, that is, a worker who does change jobs but less frequently than at least once every five years.

It is clear from Table 3.8 that there is substantial between-jobs growth in wages as market experience increases and the null of a flat experience profile of wages is rejected for fully mobile workers (Table 3.10). For instance, the expected wage rate of a fully mobile worker with 11 to 15 years of market experience is 35 per cent higher than the expected rate of a worker in the base group while the expected wage rate of a worker with a minimum of 16 years of experience is 75 per cent higher than the base. Evidence that at least a part of this growth in wages with experience is the return to on-the-job skill formation or match improvement through mobility is provided by the first column of Table 3.9, from which we read that the expected relative marginal product of a fully mobile worker also grows with experience albeit at a decreasing rate. The null of a flat experience profile of marginal productivity is also rejected for the such a worker even more easily than the null that the experience profile of his wage rate is flat (Table 3.10). Notice also that marginal productivity grows faster than the wage rate for a fully

Table 9: Estimated Experience- Seniority Profile of Relative Marginal Productivity.

	LEVEL OF JOB SENIORITY			
		$\delta_g \delta_{gh}$		
EXPERIENCE:	5 years or less (δ_g)	6-10 years	11-15 years	16 years or more
5 years or less	1.0000			
6-10 years	1.6486	1.3366		
	(0.44986)	(1.0953)		
11-15 years	2.2532	0.5870	2.4100	
	(0.46532)	(0.7645)	(1.3722)	
16 years or more	1.7882	-0.1483	0.4763	2.7525
	(0.58717)	(0.96991)	(1.0204)	(0.96026)

Note: Standard errors in parentheses.

mobile worker. Thus, as market experience increases from 5 to 10 years, expected marginal productivity grows to 65 per cent higher than the base. A further five year increase in experience more than doubles expected marginal productivity relative to the base. Marginal productivity falls as experience increases from then onwards. However, the expected marginal product of a fully mobile worker with at least 16 years of market experience is still nearly 80 per cent higher than the base. It is not surprising, therefore, that the null that the experience profile of marginal product is identical to the corresponding wage profile is easily rejected for a fully mobile worker (Table 3.10). This is evidence that at least some of the observed between-jobs growth in marginal productivity is the return to general skill formation, since the test outcome is primarily a consequence of a worker with 15 years or less of experience being paid less than marginal product while there is no evidence that δ_g is different from λ_g for older workers. On the other hand, the null that mobility gains have nothing to do with the observed between-jobs growth in marginal productivity is also rejected. Estimates of δ_{32}, δ_{42} and δ_{43} are all significantly less than unity (Table 3.7) as a result of which the estimate of $\delta_3\delta_{32}$ is significantly smaller than that of δ_3 while estimates of $\delta_4\delta_{42}$ and $\delta_4\delta_{43}$ are both significantly smaller than that of δ_4 (Table 3.9). The overall conclusion to be drawn from the estimated experience profiles of marginal

Table 10: P-Values of Wald Tests of Restrictions on Marginal Product and Wage Profiles.

Restriction	P-value
Flat experience profile of the wage rate, i.e., $\lambda_g = 1$, $g = 2, 3, 4$	0.02247
Flat experience profile of marginal product, i.e., $\delta_g = 1$,l $g = 2, 3, 4$	0.00011
Identical experience and seniority profiles of marginal product and the wage rate, i.e., $\lambda_g = \delta_g$,, $g = 2, 3, 4$	0.00362
Flat job-seniority profiles of the wage rate, i.e., $\lambda_{gh} = 1$, $2 \leq h \leq g$, $g = 2, 3, 4$	0.85735
Flat job-seniority profiles of marginal product, i.e., $\delta_{gh} = 1$, $2 \leq h \leq g$, $g = 2, 3, 4$	0.00001
Identical job seniority profiles of marginal product and the wage rate, $\lambda_{gh} = \delta_{gh}$, $h \leq g$, $g = 2, 3, 4$	0.08357
Flat experience and seniority profile of the wage rate i.e., $\lambda_g \lambda_{gh} = 1$, $2 \leq h \leq g$, $g = 2, 3, 4$	0.03679
Flat experience and seniority profile of marginal product, i.e., $\delta_g \delta_{gh} = 1$, $2 \leq h \leq g$, $g = 2, 3, 4$	0.05499
Equality of Relative Wages and Relative Marginal product, i.e., $\lambda_g \lambda_{gh} = \delta_g \delta_{gh}$	0.03011

productivity and wages for a fully mobile worker is then two-fold. First, there is evidence that at least a part of the observed between-jobs growth of wages is due to between-jobs growth in marginal productivity and, hence, must be regarded as the result of match improvement or return to on-the-job skill formation. Secondly, the observed between-jobs growth in marginal productivity is in part due to on -the-job skill formation and in part reflects the improvement match through mobility.

The fact that $\delta_{gh} < 1$ whenever $h < g$, as estimates in Table 3.7 indicate, means that job-matching effects are a significant influence in the job-seniority profile of marginal productivity. However, such effects are by no means the only determinant of the profile. As can be seen from the same table, the null $\delta_{gg} = 1$ cannot be rejected for any value of g. However, the estimated job-seniority profile of marginal productivity is rising at each level of experience from seniority level two onwards, that is, the estimate of δ_{gh} increases with h provided $h \geq 2$. Since job-match effects do not increase with seniority this can only be evidence that more senior workers have greater endowment either of firm specific capital or of unobserved ability. In principle the rise in the job-seniority profile of marginal productivity may not have anything to do with specific skill formation. However, two observations suggest otherwise. First, although the null of a flat job-seniority profile of the relative wage cannot be rejected (Table 3.10), the estimated profile follows the same U-shape as the seniority profile of relative marginal productivity. Secondly, the null that the two profiles are identical is rejected (Table 3.10) essentially because $\delta_{gh} < \lambda_{gh}$ whenever $h < g$ for $g, h \geq 2$, which is consistent with the financing implications of the specific skill formation hypothesis.

3.2.2 The Earnings Function Evidence

The picture emerging from the results of the estimation of the experience-seniority profiles of relative marginal productivity and the relative wage is thus one in which both on-the-job skill formation and job-matching are significant sources of the growth of wages with market experience and job seniority. In Tables 3.11 to 3.13, I present results of the analysis of individual level earnings data with the aim of forming some idea of the magnitude of job-matching effects relative to returns to skill formation in the observed between -jobs growth of marginal productivity. Ordinary least squares parameter estimates of alternative specifications of the earnings function as a quadratic and as a quartic are given in Table 3.11. The standard quadratic specification is rejected at the 5 per cent level in favour of the quartic, which is regarded to be superior to the quadratic in that it largely eliminates the tendency of the quadratic to understate earnings growth for younger workers while overstating it for those in the middle age group (Murphy and Welch, 1990).[15] Results of the first step of Topel's two-step IV estimator as reported in Table 3.12 are therefore based on the quartic specification. A comparison of the main 'effects' of experience and job-seniority as read from the same table with the corresponding OLS parameter estimates of the quartic specification in Table 3.11 shows that the latter are very much biased up for the true return to seniority as a result of the correlation of unobserved ability with job tenure. By removing this bias the first differencing leading to the specification underlying Table 3.12 brings the estimate of the sum of the true returns to experience and seniority-i.e., of $\alpha_1^s + \alpha_2^s$- for a new entrant to the labour market down from nearly 13 per cent a year to just over 8 per cent per year.

Results of the second step of Topel's procedure are reported in Table 3.13. The first column of this table is the constant term of the specification estimated in Table 3.12. The second and third column are estimates of the coecoefficients of X_{1ij}^0 and $-X_{1ij}^0$ obtained by applying least squares to the first and second equations, respectively, of 3.42 extended to the case of a full quartic specification and to include the usual control variables of schooling, gender, industry and employer size.[16] The fourth column is the estimate of the coefficient of X_2 in the estimation of the extended form of the first equation of 3.42. The first column entry tells us that, once we remove mobility gains and returns to unobserved ability, the hourly wage of a new entrant to the labour market will grow on the average by just 8 per cent during the first year as the sum of the true returns to market experience and job seniority. The entry of the third column then tells us

[15]Using US data, Murphy and Welch find that the quadratic specifcation 'undestates early career earnings growth by about 30-50 per cent and midcareer growth by 20-50 per cent'. They also find that the quartic specification reduces this 'bias' by more than 90 per cent while the cubic specfication reduces it by 75 per cent.

[16]Thus, in place of the first equation of 2.42, I estimate $\ln w - \chi_1 \widehat{\Gamma} = X_1^0 \alpha_1^s + X_2(a_1^\phi + a_2^\phi) + Z\gamma + e_1$, where Z is a vector of control variables, γ is the vector of coefficients of the same, $\chi_1 = (X_1, \Delta X_1^2, \Delta X_1^3, \Delta X_1^4, \Delta X_2^2, \Delta X_2^3, \Delta X_2^4)$ and $\widehat{\Gamma}$ is the vector of coefficient estimates reported in Table 3.8. Likewise, in place of the second equation of 2.42, I estimate $\ln w - \chi_2 \widehat{\Gamma} = -X_1^0 \alpha_2^s + Z\gamma + e_2$, where χ_2 has the same elements as χ_1 with the exception of its first element which is X_2. In either case X_1^0 is instrumented by X_1.

Table 11: Ordinary Least Squares Estimates of Earnings Function Paramentes.

	Dependent Variable= LNRWAGE			
Variable	Quadratic		Quartic	
	Coefficient	Standard Error	Coefficient	Standard Error
EXPR	0.044538	0.0037852	0.026903	0.0164420
EXPRSQ	-0.0006806	0.0000614	0.0008287	0.0010000
EXPRCB			-0.0000421	0.0000227
EXPRQR			0.0000004	0.0000002
TENURE	0.031009	0.0057548	0.0968890	0.0234140
TENURESQ	-0.0003587	0.0001578	-0.0073473	0.0022227
TENURECB			0.0002527	0.0000774
TENUREQR			-0.0000028	0.0000009
EDUC1	0.17180	0.042047	0.16327	0.042384
EDUC2	0.61613	0.045326	0.61406	0.045491
EDUC3	1.3892	0.069187	1.3828	0.069312
FEMALE	0.27134	0.030667	-0.2713	0.030584
YEAR95	0.11646	0.025405	0.12432	0.025557
SIZE295	-0.13436	0.067478	-0.12872	0.067392
SIZE395	-0.19716	0.066079	-0.18315	0.066148
SIZE495	-0.02115	0.072875	-0.01002	0.067868
SIZE595	0.11956	0.041081	0.13674	0.07311
constant	-0.92294	0.064719	-1.0303	0.10192
$\overline{R}^2$	0.47		0.48	
Number of Observations	2896		2896	

Table 12: Estimates of Parameters of Within-Job Wage Growth.

Dependent variable=ΔLNRWAGE		
Variable	Coefficient	Standard Error
contant	0.082452	0.01786
ΔEXPRSQ	-0.0009394	0.000503
ΔEXPRCB	-0.0000066	0.00002
ΔEXPRQR	0.0000001	0.0000002
ΔTENURESQ	-0.0057391	0.0025158
ΔTENURECB	0.0002225	0.0001025
ΔTENUREQR	-0.0000026	0.0000012
$\overline{R}^2$	0.03	
Number of Observations	1448	

Table 13: Two-step IV Estimates of First Order Effects of Job-matching, Experience and Job Seniority on Within-Job Wage Growth.

	PARAMETERS			
	$\alpha_1^s + \alpha_2^s$	α_1^s	α_2^s	$a_1^\phi + a_1^\phi$
ESTIMATE	0.082452	0.06971	0.012753	0.036001
	(0.01786)	(0.00239)	(0.0023851)	(0.0021262)

Note: Standard errors in parentheses.

that at least 15 per cent of this within-job growth in wages is return to job-seniority leaving the balance as the maximum possible annual return to market experience. This is consistent with the evidence, reported in earlier sections, in favour of specific skill formation being a source of within-job wage growth. However, the magnitude of the estimate also suggests that the true return to job-seniority in general and, hence, the return to specific skill formation in particular, may well account for a very small fraction of the observed within-job wage growth.

The entry of the last column of Table 3.13 consistently estimates the net gain to mobility, $a_1^\phi + a_2^\phi$, at the end of the first year. It tells us that the hourly wage of a new entrant to the labour market would grow on the average by 3.6 per cent at the end of the first year purely as a result of match improvement

Table 14: Earnings Function Estimates of Return to Skill Formation and Mobility Gains by Level of Market Experience.

Level of Experience:	(1) $\widehat{\lambda}_g^{IV}$	(2) $\widehat{\lambda}_g^{IV}\widehat{\lambda}_{gg}^{IV}$	(3) $\widetilde{\lambda}_g$	(4) $\widehat{a_g^{\phi} + a_{gg}^{\phi}}$	(5) =(4)/[(2)-1]
5 years or less	1.0000				
6-10 years	1.3740 (0.04657)	1.1642 (0.18268)	1.1555 (0.04076)	0.3103	1.89
11-15 years	1.7454 (0.14453)	1.1815 (0.4279)	1.2929 (0.1114)	0.6405	3.53
16 years or more	2.7201 (1.2071)	1.8401 (0.2937)	1.1522 (0.5321)	2.2192	2.64

Note: Standard errors in parentheses

through mobility, i.e., as return to the growth in the information available to the worker regarding prospective job matches. This is a very high figure compared to the estimate of the sum of the true returns to experience and job-seniority for a non-mobile worker as reported in the first column of the table. Indeed the ratio of net mobility gain to the sum of the true returns to experience and seniority grows dramatically beyond the first five years of time in the labour market to a point where mobility gains are the dominant source of between-jobs wage growth. This is what is read in Table 3.14. In the first and second columns of this table, I have used the values of $\widehat{\alpha}_1^{IV}$ and $\widehat{\alpha}_2^{IV}$, as reported in Table 3.13, and estimates of coefficients of changes in second and higher powers of X_1 and X_2, as reported in Table 3.12, to calculate $\widehat{\lambda}_g^{IV}$ and $\widehat{\lambda}_g^{IV}\widehat{\lambda}_{gg}^{IV}$. The base wage relative to which these measure between-jobs and within-job growth at experience level g is the hourly wage of a worker at 2.75 years of time in the labour market and 2.75 years of time on the current job, 2.75 being the mid point of the base interval of 0 to 5.5 years.[17]

[17]Since $\widehat{\lambda}_g^{IV}$ is biased up for the expected relative wage, it is not surprising that figures

Values of $\widetilde{\lambda}_g$ are reported in the third column of the table. Entries in the fourth column of the Table are estimates of net mobility gains at experience level g, obtained by subtracting third column entries from the corresponding entries in the first column and dividing by 0.7065 which the estimated value of $\gamma_{12}/(1-\gamma_{12})$. In the last column I express entries of the fourth column as ratios of $\widehat{\lambda}_g^{IV} \widehat{\lambda}_{gg}^{IV} - 1$. As pointed out earlier, each ratio consistently estimates a lower bound to the magnitude of net mobility gains to the return to skill formation at a given level of experience level g. The figures range from 1.89 for workers in the experience range of 5-10 years to 3.53 for workers in the experience range of 10-15 years. Thus, while estimates of the firm level average productivity and wage equations show that both mobility gains and general skill formation are significant influences in the between-jobs growth of wages and productivity, the earning function evidence is that mobility gains are by far the more important of the two sources.

4 Summary and Conclusion

In what I believe is the first attempt at simultaneous testing of the skill formation and job-matching hypotheses of wage growth, this chapter has analysed production and labour market data from a random selection of small and medium sized manufacturing firms in Ethiopia. The key step in the analysis is the joint regression of the log of the average productivity of hours in the firm and the log of the average hourly earnings of its employees on the relative shares of experience-seniority categories of the work force in total hours in the firm. The value of this as a technique is that it generates experience-seniority profile matrices of marginal productivity and wages on which the skill formation and job-matching hypotheses impose well known restrictions. According to the test result reported in the chapter, both skill formation and job-matching produce significant between-jobs growth of marginal productivity with market experience, which must account for at least a part of the observed between-jobs growth of wages with experience. However, an earnings function analysis of data on workers sampled from the firms and period

in the first column of the table are much higher than the corresponding entries in Table 3.8. It is not surprising either that figures of the second column ot the table are much lower than the corresponding figures for within-job growth as read from Table 3.8 since the latter are baised up for the sum of the true returns to experience and seniority while $\widehat{\lambda}_g^{IV} \widehat{\lambda}_{gg}^{IV}$ is not.

for which the productivity and wage profile matrices were estimated leads to the conclusion that job-matching is by far the more important of the two sources: net mobility gains account for at least twice the share of the return to skill formation in the observed between-jobs growth of wages with market experience. This figure is extremely high compared to the figure of 0.5 reported by Topel and Ward (1992) for US workers with 10 years or less of time in the labour market, and even higher than those suggested for US workers in the same age group by Mincer and Jovanovic (1981) and Bartel and Borjas (1981). Although the rate of return to formation is much higher for US workers than workers in Ethiopia, the US rate of return to skill formation as reported, for example, by Topel (1991) is at most 50 per cent higher than the figures I calculate for my sample of workers. I, therefore, conclude that the higher ratio of mobility gains to the return to skill formation for Ethiopia is in part a reflection of higher scarcity value of labour market information for workers in Ethiopia, which should not be surprising in view of the evidence, reported in section 3.3.1, that the flow of labour market information is much more restricted in Ethiopia.

Tests of the skill formation hypothesis have to date been overwhelmingly dominated by earnings function analysis (e.g., Haley, 1976; Lillard and Weiss, 1979; Hause, 1981; Neumark and Taubman, 1995; and Baker, 1997) as have been those of the job-matching hypothesis (e.g. Flinn, 1986; Altonji and Shakoto, 1987; Marshal and Zarkin, 1987; Farber and Abraham, 1987; Garen, 1989; Topel, 1988, 1991; and Topel and Ward, 1992). Indeed, I am aware only of three studies in which data on workers' productivity are directly analysed in testing models of wage determination, namely, Medoff and Abraham (1980), Blackmore and Hoffman (1989) and Hellerstein and Neumark (1995). The Medoff and Abraham study compared employee earnings in two large US manufacturing corporations with supervisors' performance evaluation data to conclude that on-the-job skill formation could not explain 'a substantial part of the observed return to labour market experience'. In spite of the acknowledged limitation of performance evaluation scores as a proxy for productivity, this result remains the only direct evidence in favour of alternatives to the human capital explanation of a rising experience profile of earnings. The study by Blackmore and Hoffman went beyond the case study scope of the Meddof and Abraham paper in analysing aggregate time series productivity and earnings data on the US manufacturing sector as a whole. However, it was concerned exclusively with the influence of job-seniority on productivity and wages. Its results were therefore not comparable with those of the Medoff and Abraham paper. The Hellerstein and Neumark paper was a significant step forward in terms of direct use of observations on productivity by using firm level data and was, indeed, the first attempt at the joint estimation of marginal productivity and wage profiles as the basis for testing the skill formation hypothesis. Unfortunately the authors focused on age profiles to the exclusion of job-seniority profiles without which job-matching effects could not be tested for.[18]The methodological contribution of this paper is to extend the Hellerstein and Neumark specification into a framework in which one can simultaneously test for both skill formation and job-matching in cross section data.

[18]Hellerstein and Neumark were also forced by data limitation to consider profiles only for those in the middle or at the end of their career, which meant they could not use the experience profile they estimated even to test for skill formation.

5

Appendix: Coefficients of Control Variables In Non-Linear SUR Estimation of Average Level Productivity and Wage Equations of Table 3.7

Control Variable	Average Wage Equation		Productivity Equation	
	Coefficient	Standard Error	Coefficient	Standard Error
DPRIM	0.0418	0.1440	0.2724	0.1448
DSEC	0.0294	0.1359	0.0489	0.1377
DVOC	0.40375	0.1883	0.4356	0.1912
PROFEM2	0.3795	0.1827	0.3027	0.1858
PROFEM3	-0.0784	0.1736	-0.0673	0.1764
PROFEM4	0.3479	0.2385	0.249	0.2402
CRAFT	0.2170	0.1830	0.1756	0.1863
BATCH	0.3746	0.2332	0.1675	0.2351
TEAM	0.0471	0.1505	0.015	0.1522
SIZE2	0.25927	0.1719	-0.02714	0.1862
SIZE3	-0.1865	0.1975	-0.2266	0.2443
SIZE4	0.1725	0.2948	0.053	03659
SIZE5	0.9227	0.5227	-0.8276	0.5913
AGE2			-0.0102	0.1406
AGE3			0.0174	0.1197
AGE4			-0.004	0.1386
EQAGE2			0.1859	0.1157
EQAGE3			0.0991	0.1285
EQAGE4			-0.1194	0.1295
YEAR95	-0.4878	0.1270	-0.4953	0.1285
TEXT	-0.1211	0.2807	-0.6158	0.2869
KNIT	0.0822	0.2260	-0.2333	0.2332
GARM	0.0693	0.2006	-0.0047	0.2048
WOOD	-0.09	0.2163	-0.31460	0.2175
LEATH	0.3058	0.2029	-0.0914	0.2044
OTHIND	0.5111	0.2083	0.1159	0.2085

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